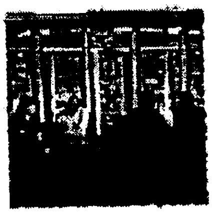
DSC
COMMUNICATIONS

Unbundling Solutions



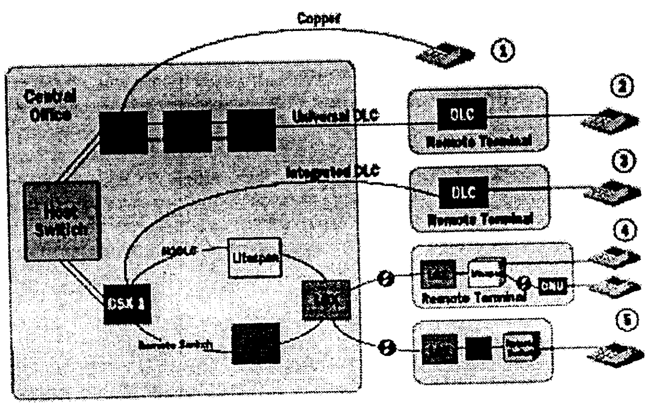
The Challenge

One of the three key principle goals set forth by the Telecom Act of 1996 is "opening of the local exchange and exchange access markets to competitive entry". This has created a demand for low-risk, low-cost, easily implementable solutions that support continued profitability.

Section 251 of the legislation imposes specific obligations on telecommunication carriers including, Sec 251 (c), which states that an ILEC must provide to any requesting telecommunication carrier, LEC retail services for resale to at wholesale rates and interconnection and access to network elements on an unbundled basis at any technically feasible point. Network Elements are defined as a facility or equipment used in the provision of a telecommunication service. Interconnection refers to the physical linking of two networks for mutual exchange of traffic. One of the technically feasible points is the local loop, defined in the Act as a transmission facility between the distribution frame of the ILECs Central Office and the NID.

Unbundling of the local loop is essentially the leasing of the local loop facility from the end office to the subscriber. The type of loops include: 2&4 wire analog voice grade, 2&4 wire unconditioned loops supporting ISDN, ADSL, HDSL, LNP and DS1 signals.

Unbundling: Five methods of providing local loop access



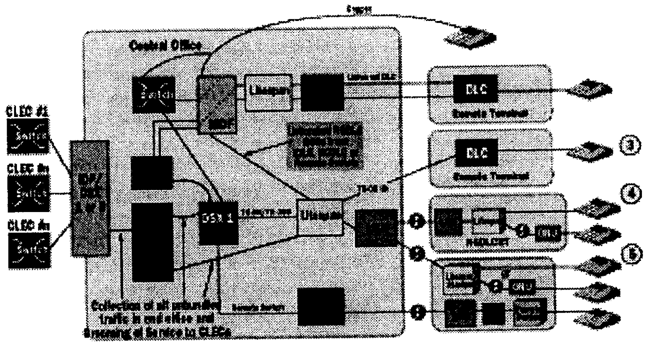
Service is provided to the local loop over one of five different and distinctly different technical means. The five different methods of providing local loop terminations are:

1. Host Switch, direct VF terminations
2. Universal Digital Loop Carrier VF terminations
3. Integrated Digital Loop Carrier Digital terminations
4. Integrated Digital Loop Carrier Digital terminations
5. Remote Switch terminations

All five methods of service delivery provide equivalent service to subscribers, but are impacted differently when required to be unbundled.

There is no problem with unbundling of a host switch and universal Digital Loop Carrier VF termination since they appear directly on the MDF in the most basic form, at the VF level. In some ILECs as much as 40% of the existing loops are digitally derived. The problem with digital derived switch interfaces, however, is that they do not allow for unbundled access to the individual subscriber loops in the central office.

Unbundling for NGDLCs, IDLCs and Remote Switches with DEXCS Collecting and Grooming CLECs service



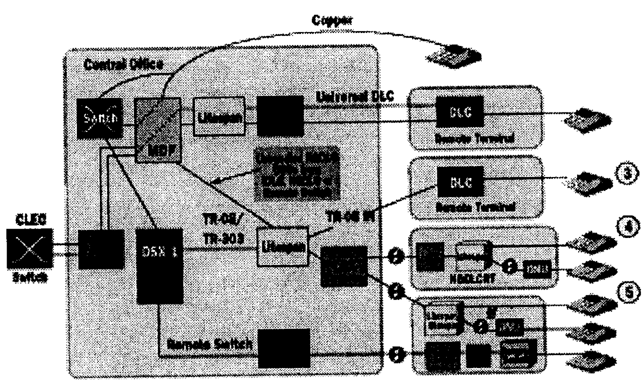
DSC Unbundling Solutions

Unbundling for Integrated Digital Loop Carriers can be performed by utilizing the DSC Litespan Next Generation Digital Loop Carrier (NGDLC) with its Time Slot Interchanger. The TSI allows "mapping" of the DSOs in the digital interface to be mapped to an analog interface. Any of the subscribers that remain terminated in the ILECs domain are digitally interfaced, same as before. The subscriber making the transition to the CLEC can be "mapped" to a VF circuit at the MDF for re-route. By implementing the Litespan NGDLC, only the required unbundled derived loops have to be treated. The only other option is to deploy Central Office terminals to gain VF access of a digitally terminated subscriber. In many cases, switch expansion and switch re-balancing must occur to support the treatment of the IDLC unbundled loops by implementing a COT.

Remote switches present a different problem. Remote switches are placed to provide service and are connected to the host serving switch with a proprietary digital umbilical link. This link is concentrated with the remote switch taking an appearance as an extended line peripheral bay off the host switch. Any unbundled loop request will require the "nailing up" of the derived loop. The circuit is nailed up over the umbilical link and also through the switch fabric eventually to the MDF. To support unbundling in the remote switch option, a Litespan Remote Terminal or Starspan Optical Network Unit can be placed with the remote switch. The local loops required to be unbundled are transferred to the Litespan system for MDF access in the host serving office.

Implementing a Litespan solution is the most effective way of providing unbundled loop access to digitally derived local loops. Another key benefit is the capability to provide "flow through" service order provisioning with the established loop OS systems. This includes the capability to provide Metallic Loop Testing (MLT) of any unbundled loop.

Unbundling for NGDLCs, IDLCs and Remote Switches



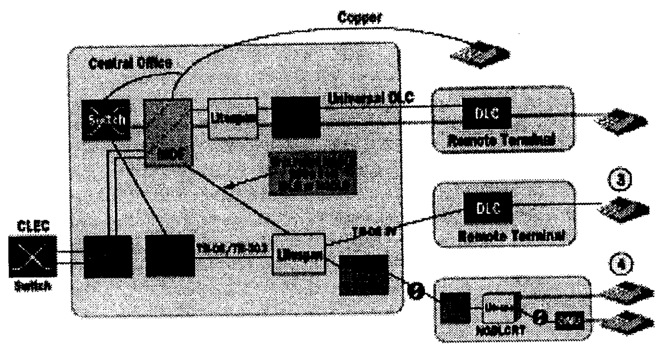
The second part of unbundling support is the mapping of the unbundled loops into the transport and IOF network. This critical network component is supported by the DSC DEXCS platform. The DSC DEXCS used in conjunction with Litespan addresses both: terminating and routing traffic from multiple CLECs into the end office; and collecting and routing traffic from the end office to a hub office where multiple CLECs are co-located.

In the end office domain, the DEXCS collects the service at a DS1 or TR-008 interface level and provides the capability to re-route the unbundled loops in a digital format to the required CLEC. DEXCS is compatible with IOF testing methods.

There is also the option of implementing the DEXCS at a hub site in which a single collection point of unbundled traffic from the end offices occurs. At this hub office, the DEXCS can terminate DS1 traffic (DS1 or TR-008 formatted), DS3 or at a STS-1 interface. The DEXCS provides DS0 observation and mapping of the unbundled loop to any CLEC that has an appearance in the hub office.

The DSC unbundling solutions are also supported by the foundation Operational Support Systems (OSS) deployed today. The access network is maintained and provisioned by OSSs designed to log data and support the service delivery of a mass market offering. The transport network OSSs differ in that they were designed to maintain records from the serving wire center, to the Inter Office Facilities (IOF) domain and to the terminating wire center. The OSSs bond since they both link at the point of interconnection as the services transverse each domain.

Unbundling for NGDLCs and IDLCs



The DSC product offerings for support of the unbundling provide key benefits including:

- Complete TSI capability to support grooming, routing and mapping of the unbundled loop.
- Network compliant interfaces of:VF interface (2 wire & 4 wire), ISDN, DS1, TR-008, GR-303, and DS3 rate.
- Tested interoperability with established TR-008 DLCs
- Embedded Operational Support capabilities of both the loop and Inter-Office environment for end to end flow through order capabilities and testing.
- Software controlled network elements supporting new and merging services including SDSL, HDSL, LNP and ADSL.
- Opportunity to increase the Return On Net Assets of existing infrastructure by implementing other DSC Asset Value Drivers on Litespan and DEXCS platform.
- Network solution supporting the initial demand for unbundling and future opportunity to transition unbundled loop to other CLECs, or back to the ILEC domain on a remote order provisioning basis.

Return to find the DSC Solution for your challenge...

The Virtual RDT, Key to Unbundling the Local Exchange

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1. Abstract.

Competition in the Local Exchange is no longer merely a topic of speculation. It is happening, now, at a blinding pace. Local Exchange Carriers (LECs) are being forced to make some serious decisions that will effect their future for decades to come. Both the business and technical foundations of over 100 years are now rapidly changing.

Some RBOCs and other LECs are "unbundling"; divesting themselves of some part of their current holdings in order to receive the required Regulatory and Judicial blessings to enter competitive markets. At this point (May 1993), Rochester Tel, Pacific Telesis and Ameritech have either unbundled or stated their intention to do so. A keystone in the LEC's unbundling strategies is Open Network Architecture (ONA).

This paper builds on a technical concept introduced at last year's NFOEC by John Eaves and Paul Zimmerman of Bellcore in a paper titled "Impact of SONET on the Evolution of Telecommunications Network Architectures and Switched-Service Capabilities". Their paper showed how the capabilities of Integrated Digital Loop Carrier (IDLC) systems conforming to Bellcore TR-303 [1] can be used to provide sophisticated switched services to any subscriber in a LATA from a small number of host switches.

2. Overview of Integrated Digital Loop Carrier as defined in TR-303.

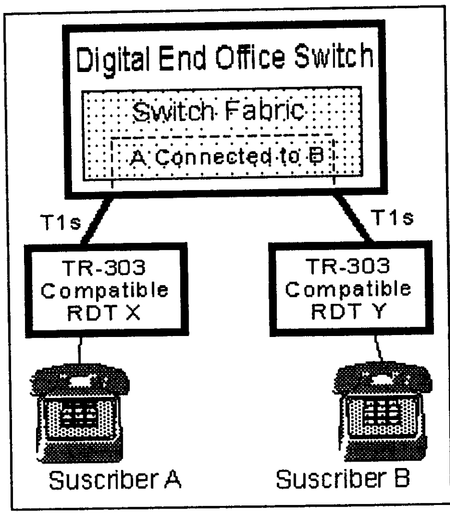
The focus of much attention these days is the local loop. Synchronous Optical Network (SONET), Fiber in the Loop (FITL) and IDLC as defined in TR-303 are closely related key technologies which are helping to redefine the local loop. Figure 1 shows a pair of IDLC Remote Digital Terminals (RDTs) subtended from a digital switch using an integrated interface over copper DS1s. The blocks on this figure could just as well represent the previous generation of DLCs, such as the SLC®-96(1). But, the similarity is only skin deep.

A TR-303 compatible RDT is more like a Remote Switch Unit (RSU), with an open, non-proprietary, interface to the host switch, than it is like a conventional DLC. While a TR-303 RDT does not switch calls locally, a single RDT can handle up to 668 simultaneous DS0 bearer connections to a switch. By comparison, a standard 5ESS Switching Module handles 255 DS0 bearer connections to the 5ESS Time Multiplex Switch [2]. A typical IDLC contains more computer processing power than many currently deployed 5ESS Switching Modules [2] or even the NT-40 processor which is the core of a standard DMS-100 [3] switch. An IDLC uses common channel signaling to communicate at 64 Kbps with the host switch. This Common Signaling Channel uses a version of the Q.931 protocol to support call setup which allows more subscriber lines to be served than there are DS0 circuits back to the host switch. This concentration feature can efficiently support concentration ratios of 8 or 9 to 1 while maintaining required grade of service to residential subscribers [4,5].

Figure 1. Call setup between two TR-303 compatible Remote Digital Terminals (RDTs) attached to digital End Office Switch via point to point DS1 copper facilities.

Subscriber A goes off-hook. RDT X sends CSC message to Switch. Switch selects available time-slot to RDT X and sends X a CSC message directing X to connect A to the specified time-slot back to the switch.
Switch provides dial tone to subscriber A.

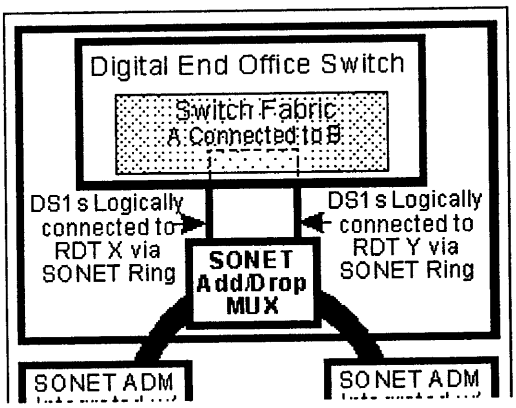
Subscriber A dials destination number. If DTMF dialing is used, switch collects digits. If subscriber uses dial pulse, digits are collected by RDT X and sent to Switch via a CSC message.
Switch determines that call is destined to subscriber B on RDT Y.



Switch connects time-slot from A to a time-slot goint to RDT Y using Internal Switch Fabric.
Switch sends CSC message to RDT Y specifying the time-slot from subscriber A and an alerting cadence for ringing.
RDT Y connects specified time-slot from switch to subscriber B and rings subscriber B's phone.
When subscriber B answers, RDT Y sends a CONNECT CSC message to the Switch to indicate that the call setup is complete.

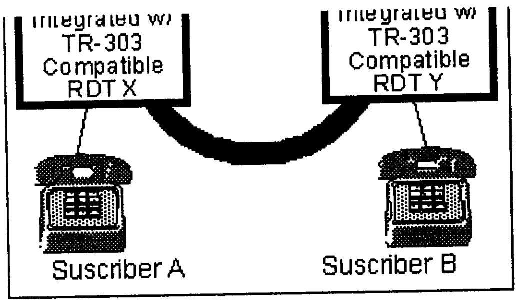
Figure 2. Call setup between two TR-303 compatible DLCs attached to digital End Office Switch via SONET Ring.

Subscriber A goes off-hook.
RDT X sends CSC message to Switch. Switch selects available time-slot to RDT X and sends X a CSC message directing X to connect A to the specified time-slot back to the switch.
Switch provides dial tone to subscriber A.
Subscriber A dials



Switch connects time-slot from A to a time-slot going to RDT Y using Internal Switch Fabric.
Switch sends CSC msg to RDT Y specifying the time-slot from subscriber A and an alerting cadence for ringing.
RDT Y connects

destination number. If DTMF dialing is used, switch collects digits. If pulse dialing is used, digits are collected by RDT X and sent to Switch via a CSC message. Switch determines that call is destined to subscriber B on RDT Y.



specified time-slot from switch to subscriber B and rings subscriber B's phone. When subscriber B answers, RDT Y sends a CONNECT CSC message to the Switch to indicate that the call setup is complete.

Figure 1 illustrates how call setup is performed using a TR-303 RDT over the Common Signaling Channel[2] (CSC). The RDT on the left is shown originating a call which terminates to a subscriber on another RDT connected to the same switch. Figure 2 shows a comparable configuration with the two RDTs in Figure 1 integrated with a SONET Add/Drop Multiplexer (ADM) [6]. This permits direct connection onto a SONET OC3 fiber in either a linear or ring configuration.

The original intent of the TR-303 based IDLC was a higher capacity more efficient (concentrating) version of the traditional Digital Loop Carrier. Like its predecessors, the IDLC RDT would be installed in the loop plant.

3. Overview of Eaves and Zimmerman Paper.

In the referenced paper presented at the 1992 NFOEC, the authors presented a concept which would allow LECs to introduce new services throughout a LATA without having to upgrade hardware and software at each Central Office (CO) in the LATA. To accomplish this, TR-303 RDTs would be installed in COs, like RSUs (presumably in addition to those RDTs deployed in the loop). Such an approach limits a carrier's financial risk in introducing a new service, such as ISDN, where customer demand is uncertain. Furthermore, the service could be provided using a single switch vendor's switch(es) throughout the LATA, regardless of the switch type in the local CO, thus, ensuring that such a service would appear uniform to all subscribers. See Figure 3.

To introduce a service like ISDN, subscribers desiring ISDN would have their copper loops removed from the CO switch in their serving wire center which formerly provided them with dial tone. An ISDN subscriber's pair would be connected to an ISDN channel unit on the RDT, also located in the subscriber's serving wire center. All such subscribers within a LATA would then be provided with service from a single host switch equipped with the hardware and software to support ISDN. After reading the Eaves and Zimmerman paper, I queried numerous people within various RBOC organizations about their feelings on the idea. The intent of these inquiries was to validate Eaves' and Zimmerman's concept and to determine the degree of support it had within the Bellcore Client Companies. All those contacted were in favor. Many said that they believed that this is the only way that ISDN may ever be successfully introduced.

If additional capacity is needed for the service provided by the Host Switch, or if different services are to be provided from different Host Switches, it must be possible to provide the services from several Host Switches using the same TR-303 Remote Digital Terminal in a CO (rather than requiring a separate RDT in each CO for each Host). This is supported by what is called the "Virtual RDT" or "Multihosting". While Multihosting was not mentioned previously in TR-303, the December 1992 revision [1] addresses the subject as an optional capability in Section 12.5.10.

Figure 4 shows two Host Switches using the same RDTs in various other wire centers for access to subscribers. Those customers at each wire center who have subscribed to the services provided on Host Switch A are logically partitioned in Host Switch A's Virtual RDT while customers subscribing to the services provided by Host Switch B are assigned to B's Virtual RDT. Like ISDN, other Advanced Intelligent Network (AIN) services, or even ONA could be provided in an ubiquitous manner without upgrading all the switches in a LATA to be capable of delivering the services locally.

4. Potential Challenges.

Eaves and Zimmerman mentioned a few potential challenges associated with their approach which needed further study.

Figure 3. Host Switch in Wire Center 3 provides ISDN or other services to subscribers subtended from TR-303 compatible RDTs in each Wire Center. The single Host Switch "owns" the entire RDT at each Wire Center.

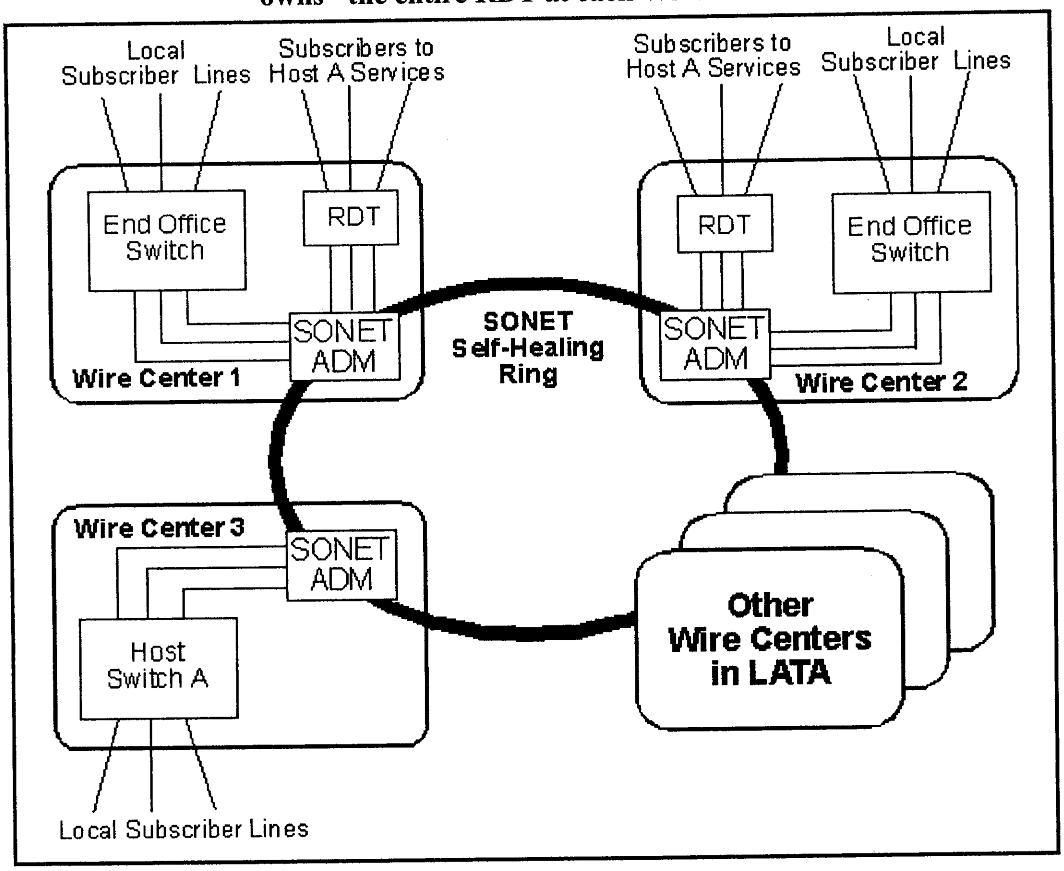
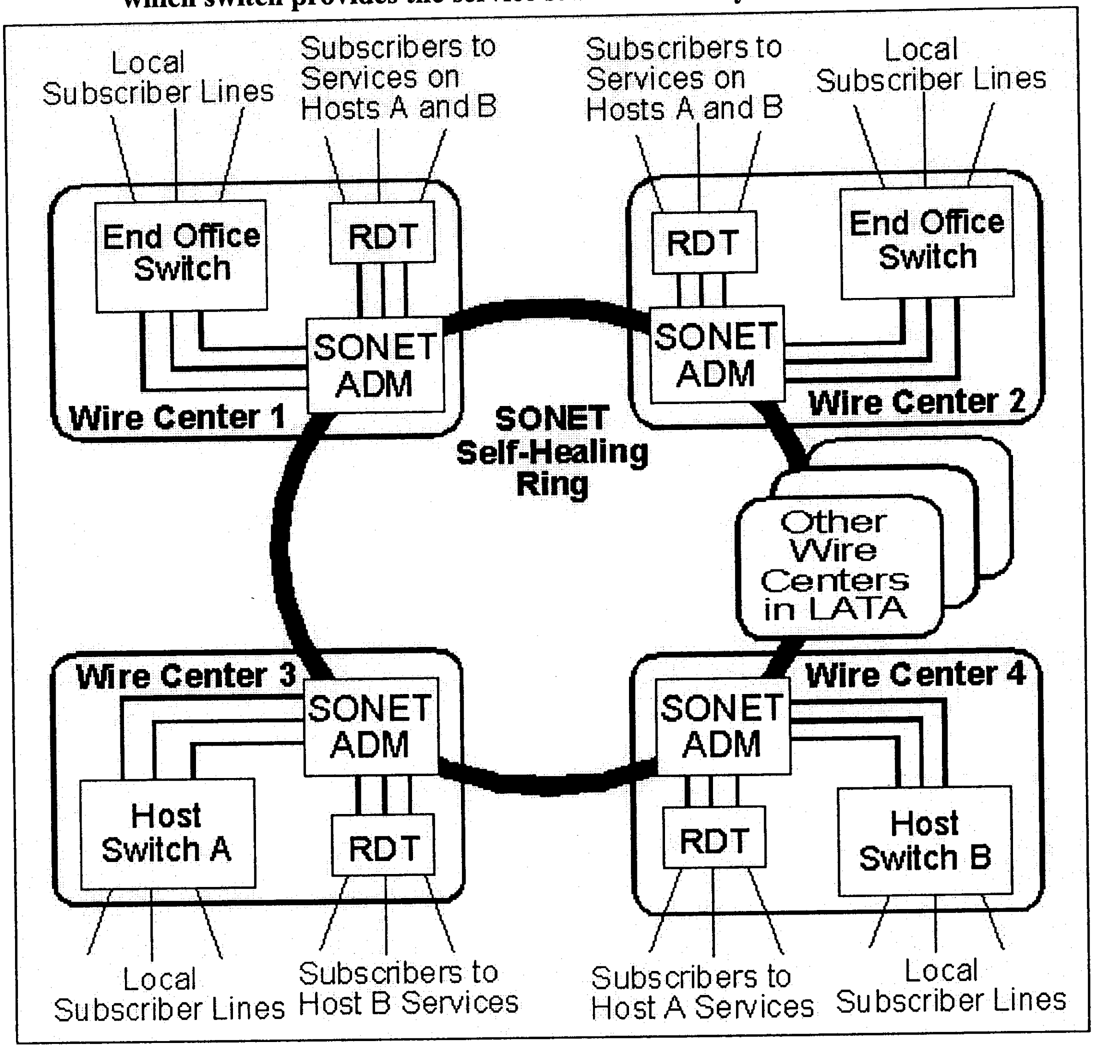


Figure 4. When services are provided using 2 or more Host switches, each physical RDT in a Wire Center provides each Host Switch with a Virtual RDT Interface. Thus, subscriber lines on each RDT are associated with a respective Host Switch based on which switch provides the service subscribed to by each subscriber.



4.1 Wire Center Boundaries.

One area of concern related to current tariffs based on existing wire center boundaries. Without regulatory relief from this artificial way of looking at the local exchange network, subscribers served from a switch outside their own local wire center might be assessed an additional Foreign Exchange (FX) charge.

Using a conventional DLC to extend a line from a subscriber in a certain serving wire center to a switch in another wire center is a common way of providing FX service. Thus, when a TR-303 RDT is used as described by Eaves and Zimmerman, it is easy to see how regulators might be led to consider this to be another case of FX service. If, however, a LEC installs a Remote Switch Unit or Remote Switching Module (RSM) in a wire center to serve local subscribers, the subscriber is considered to be served from the local wire center even though some services are being provided from the remotely located host switch. If Eaves' and Zimmerman's concept is presented to regulators using the RSU comparison, rather than the conventional DLC scenario, perhaps the anticipated regulatory problems will be moot.

As mentioned previously, a TR-303 compatible RDT can be viewed as an open interface RSU. The subscriber's line terminates in the local wire center. The channel unit which digitizes the POTS subscriber's voice is in the local wire center. A time-slot interchanger (circuit switch) is located in the local wire center as part of the RDT. The access provided is not dedicated as with a Foreign Exchange line (even when provided using a conventional DLC) in that a DS0 bearer circuit between the RDT and the Host Switch is not connected until the subscriber goes off-hook or until a call is received by the Host Switch which is destined for the subscriber. The facilities from a TR-303 RDT to a remote host switch are more like interoffice trunks than FX lines. Interoffice trunks are considered part of the overall switched network and are tariffed by minutes of use.

What has been described by Eaves and Zimmerman **represents an entirely new form of local access**. It is not Special Access because DS0 circuits for individual subscriber lines are not dedicated. It is not Switched Access as currently defined in that the local CO switch has no involvement in providing the access. I propose that this type of local access be called "Concentrated Access".

4.2 Number Retention/Number Portability.

With the technique proposed by Eaves and Zimmerman, a subscriber's line is logically moved from the End Office Switch to which it is currently homed, to a switch in another Central Office. The current organization of the North American Numbering Plan (NANP) and the inability of existing Central Office switches to efficiently support full 7 digit routing for individual calls would require that such a subscriber be assigned a new telephone number. This is considered a possible problem in the Eaves and Zimmerman paper.

It should first be noted that number retention is a real problem only for terminating, rather than originating, calls. True, the subscriber may frequently call a company which is making use of his originating phone number (Caller-ID) to look up his account information, for example. However, the next time he calls the company with a Caller-ID which is not in the company's database (because his number changed), the subscriber will be asked for his account information and this, along with the subscriber's new phone number will be stored in the database for future reference.

If a subscriber is "moving up" to a more sophisticated service, changing his local phone number may not be a very serious problem. The proliferation of addressable devices on an ISDN "line" has generated activity which may result in an expanded numbering plan for ISDN in the future. This would force a number change anyway. Similarly, if a subscriber is being connected to a remote host switch to access an Advanced Intelligent Network service, his actual POTS phone number may be immaterial. For example with a service like a Private Virtual Network or Area Wide Centrex, the subscriber's new POTS number at the new host would simply be placed in the translations database used to route calls to the subscriber based on his Centrex extension number or his private network directory number.

However, for a business with an investment in advertising, letterhead, etc. with the company's current phone number on it, changing of a phone number may have a significant financial down side. In this case, the subscriber should be willing to pay for a feature to retain the ability to receive calls to his previous telephone number. The essential requirement when a subscriber's phone number is changed is that callers using the subscriber's previous number must continue to be able to reach him.

If the subscriber is currently served from an end office with call forwarding, this would be the easiest solution. The subscriber's old number would simply be call-forwarded to the new number. The cost for such a feature should be much the same as conventional call forwarding. No switch equipment is dedicated to the subscriber (only database storage). The subscriber's line is no longer connected to the local CO, thus a channel unit is not required to connect to his line.

For an end office switch without call forwarding capability, the following DLC based approach is proposed. For purposes of discussion, let us consider a hypothetical customer who has decided to subscribe to an advanced service provided only from a remote host switch. This same subscriber wishes to retain his existing phone number. A call made to this example subscriber's new phone number will be routed normally to the new host switch and will terminate via the TR-303 RDT to the subscriber's line. A call to the subscriber's old number will be routed by the network to the subscriber's former End Office switch. In this example the switch is not capable of forwarding the call to the subscriber's new number on the remote host.

A software feature can be added to the TR-303 RDT to allow terminating calls from either the remote host or the local CO to connect to the subscriber's line. Some background is required in order to explain how this can be accomplished. Few if any TR-303 compatible RDTs are currently deployed in LEC networks because very few switches have TR-303 capabilities installed. However, recently deployed DLC equipment from most manufacturers is "TR-303 ready". Such systems are sometimes referred to as New Generation Digital Loop Carriers (NGDLCs). These systems currently interface to digital switches or Central Office Terminals (COTs) using Bellcore TR-08 [7] and TR-57 [8] specifications.

TR-08 is a essentially a codification of the SLC-96 DLC interface. Of course a SLC-96 only supports 96 lines, usually over 4 DS1s (with an optional protection DS1). A single RDT of a New Generation DLC can support many more lines and DS1 circuits than are defined in TR-08 (because it is really just waiting to be converted to TR-303 operation with it's much increased line and trunk capacity). Thus, in the interim, before TR-303 switch capabilities are deployed, these NGDLCs use software to support the notion of several "Virtual" TR-08 compatible RDTs. Virtual TR-08 RDTs from the same physical NGDLC can each connect to the same, or multiple, host switches or COTs (see Figure 5).

Because switches will likely be transitioned to support TR-303 one at a time, it might reasonably be necessary for a currently installed NGDLC RDT to connect to a TR-303 compatible host switch while continuing to support Virtual TR-08 interfaces to one or more other host switches (see Figure 6).

Now back to our example. The required functionality in this case is to be able to terminate a call from either the new host, or the old CO, to the subscriber's line. A contention situation must be dealt with where the subscriber is off-hook with a call connected through one switch when a terminating call for the subscriber arrives at the other switch.

Figure 5. An NGDLC RDT installed today can support more lines and DS1s than a TR-08 RDT. Thus, a single physical RDT may be configured with as many as 7 virtual TR-08 RDTs. As illustrated, these virtual TR-08 RDTs may terminate on two or more Switches in one or more Central Offices.

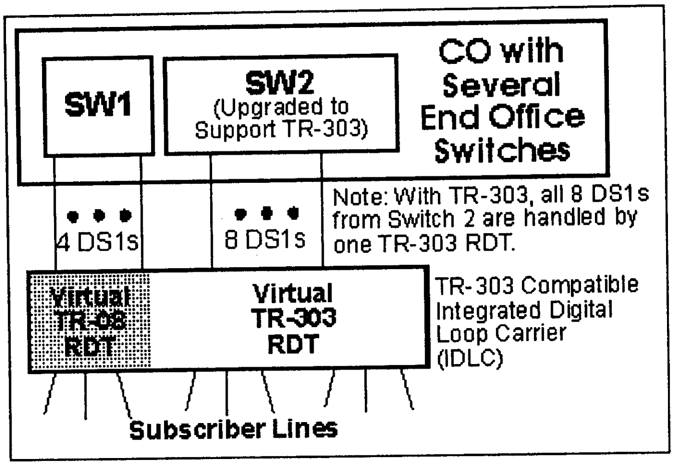
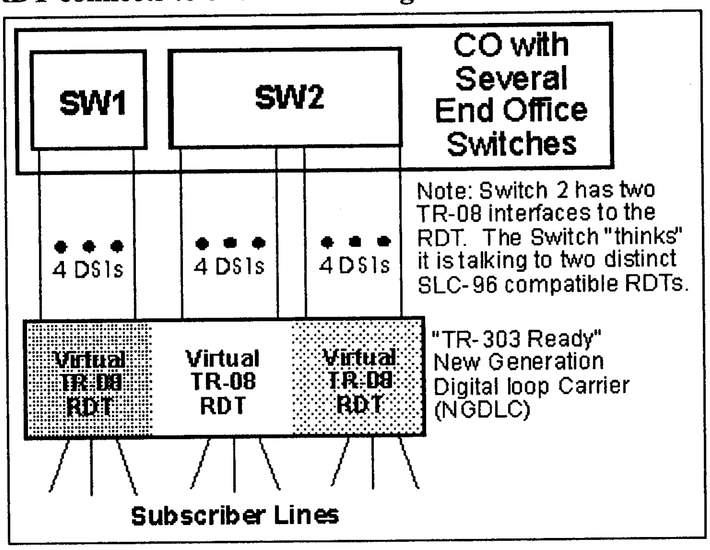


Figure 6. With a single NGDLC supporting two or more Switches, when one of the Switches is upgraded to support TR-303, it is desireable to support a configuration where the RDT connects to one Switch using TR-303 and another using TR-08.



A method is required to block (with busy signal or other appropriate treatment) an incoming call arriving either:

- at the old (local) switch when the subscriber is involved in a call connected through the new host switch; or
- at the new host switch when the subscriber is off hook connected to a call terminating through the old switch.

TR-08 defines a simplistic method for concentration of subscriber lines called Mode-II concentration. Two lines contend for a single DS0 to a digital switch or COT. This means that it is possible for a subscriber on one of a pair of concentrated lines (contending for the same DS0) to be off-hook, and thus consuming the shared DS0 resource, when the other subscriber receives an incoming call. With an integrated TR-08 interface, the RDT can notify the switch that the DS0 is busy and the incoming call can be blocked in the switch by connecting it to a busy signal or other treatment.

In our example, the subscriber's old End Office was not capable of call forwarding. Since an Integrated TR-08 interface to the switch requires a digital switch, and such a switch would probably have call forwarding, the fact that call forwarding is not available probably means that the local End Office is an analog switch. In order to access ISDN, etc., the subscriber's line was moved from the local switch to a TR-303 compatible RDT in the subscriber's serving wire center and the subscriber would draw dial tone from a new, remote, host switch. Meanwhile, the channel unit on the local switch which was previously connected to the subscriber's line would be connected to a TR-08 compatible COT which supports Mode-II concentration (see Figure 7). One or more DS1s from the COT (as required for the number of subscribers) are connected to the same TR-303 RDT to which the subscriber's line is now attached. They use the RDT's software capabilities to act as a Virtual TR-08 RDT to the COT while simultaneously functioning as a Virtual TR-303 RDT to the TR-303 capable remote host switch.

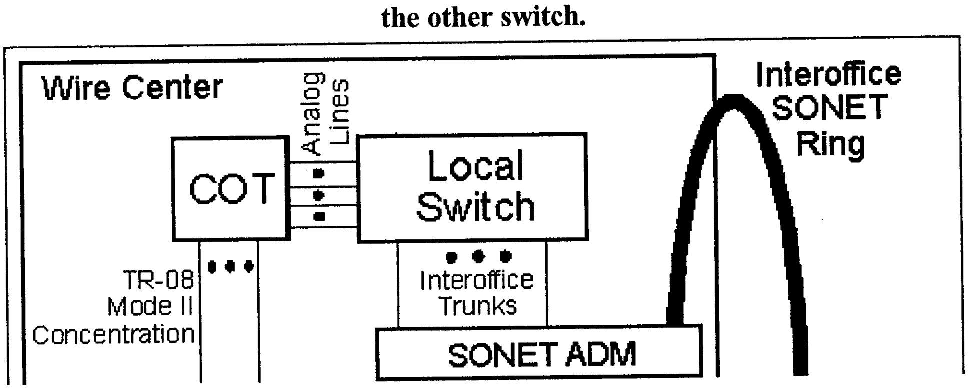
A call made to the example subscriber's new phone number will be routed normally to the new host switch and will terminate via the TR-303 RDT to the subscriber's line. If an incoming call arrives at the subscribers old End Office, the call will ring the line connected to the COT. If the subscriber's actual line is on-hook, the call can be connected to the subscriber's line on the RDT. If the subscriber is off hook when the call arrives, the RDT can send the "All Available Channels Busy" indication to the COT which causes the COT to connect the incoming call to reorder tone in accordance with TR-57 Section 7.3 [8], effectively blocking the call to resolve the contention situation.

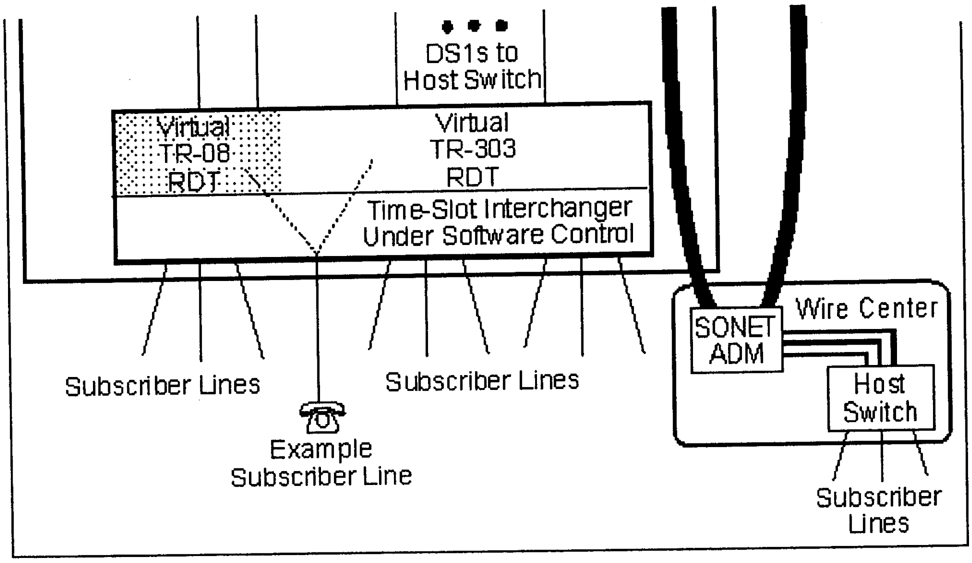
If the subscriber is talking on a call connected through the local CO when an incoming call arrives at the new host switch, the RDT can detect the condition and send an appropriate TR-303 CSC message to tell the TR-303 host switch that the subscriber is off hook and cannot receive the call. The new host switch would then connect the incoming call to a busy signal or other appropriate treatment.

4.3 Survivability.

Eaves and Zimmerman concluded that future LEC networks should migrate from today's "dense" architecture with many switches at Central Offices throughout a LATA to a "sparse" network with perhaps only three large end office switches. An obvious problem with a sparse network is survivability.

Figure 7. With the actual connection of a line to a Time-Slot under RDT software control, calls originating from the example line can be directed via the Virtual TR-303 RDT to the remote host switch. Terminating calls from either the remote host or local Switch can terminate to the same subscriber line. Terminating calls from either switch can be blocked and sent to a proper treatment if the subscriber is busy with a call from the other switch.





Survivability should not be confused with reliability. Reliability addresses failures of equipment or software within the network, whereas survivability relates to external natural or man-made events which threaten the network. Threats to survivability include: earthquakes, tornadoes, floods, hurricanes, cable cuts, hackers, terrorism and war. Switches within the network are implemented with redundant hardware for reliability. Battery power and backup generators provide reliable power. SONET self-healing rings will provide survivable transmission facilities. However, if an emergency such as an earthquake, hurricane or flood occurs, more dispersed switching resources offer greater survivability than sparse resources. Recent Government studies have shown that a sparse network is also more vulnerable to attack by terrorists and hackers [9,10].

Peter Huber and other contributors to his 1987 [11] and updated 1993 reports [12] foresaw a densely connected "Geodesic Network" (Figure 8). Such a highly interconnected network architecture would be extremely survivable [13]. In general, today's network with switching at each end office approaches the geodesic concept because the end offices are connected with many diversely routed physical facilities [13]. However, even the most sophisticated Central Office switches lack the ability to effectively utilize this connectivity because they cannot perform non-hierarchical routing [13]. Inter-exchange networks have long been capable of non-hierarchical routing using common channel signaling [14]. However, non-hierarchical routing is not supported by CO switch software, even with Common Channel Signaling System 7 (SS7) deployed in the Local Exchange [13]. With a sparse network of switches as proposed in the Eaves and Zimmerman paper, network survivability would, indeed, be lessened.

However, TR-303 multihosting offers the opportunity for an additional feature: multihoming, which could help mitigate this risk. The previous section explained how a TR-303 based RDT could terminate calls from multiple local or remote switches which are destined to the same subscriber line. With Multihoming, a subscriber would be homed to a primary switch for "primary dial tone". The RDT can tell if the subscriber's primary switch is out of service (because the switch fails to respond over the Common Signaling Channel and the Embedded Operations Channel within established timeout durations). Thus, the RDT can request service from the subscribers chosen "backup switch" (by sending a TR-303 "SETUP" message to the backup switch). Figure 9 illustrates this.

If the subscriber's main concern is being able to originate calls when his Primary Host is out of service, Multihoming meets the need with no additional effort. Suppose a subscriber is concerned with being able to receive, rather than just originate, calls in the event of an emergency (as with 800 service for example). In this case, the 800 database could store both the subscriber's POTS numbers (the one to reach the subscriber via the Primary Switch and the one to connect via the Backup Switch). If calls to the 800 number are unable to complete to the Primary Switch, the call can be routed to the subscriber's corresponding number at the Backup Switch with calls from either switch terminated to the subscriber's line via the RDT.

The section below discusses how Alternate Service Providers or Enhanced Service Providers (ESP) could use "Concentrated Access" provided with Multihomed TR-303 RDTs to provide switched services to subscribers anywhere in a LATA. With additional options available from such competitive providers, the survivability of the overall Local Exchange Network should be increased, even if existing LECs choose to implement sparse switching networks in the future.

Figure 8. Geodesic Network Example

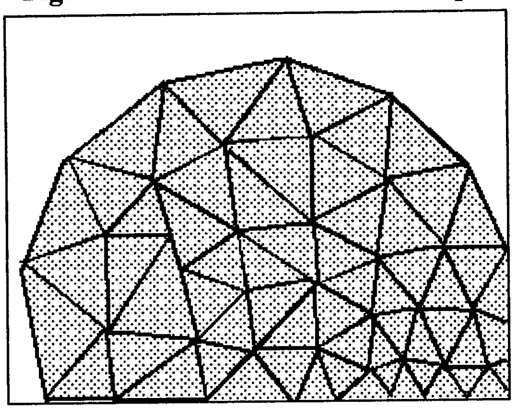
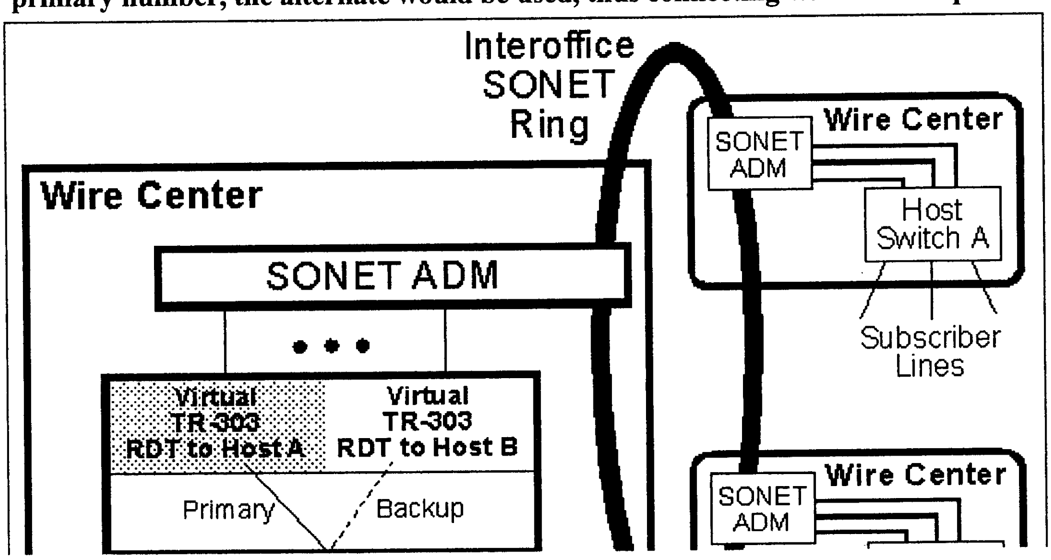
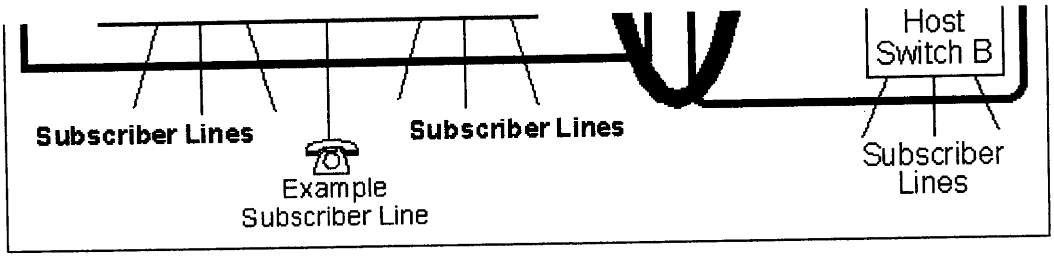


Figure 9. A subscriber could be "Multihomed" to both Host A and B with A being the Primary Host Switch and B providing backup. This would allow the subscriber to originate a call even if the Primary Host Switch were down. For terminating calls to an 800 number, for instance, alternate POTS numbers for the line on both hosts could be stored in the 800 routing database. If calls could not successfully terminate to the primary number, the alternate would be used, thus connecting via the backup host.





5. Concentrated Access.

As briefly mentioned in section 4.1, the concept presented by Eaves and Zimmerman, combined with Multihosting, defines a new form of Local Access. In addition to Special Access and Switched Access, we now have Concentrated Access.

The access provided is concentrated in that:

- Subscriber lines generate modest network traffic and can generally be served by fewer trunks to the host switch than actual subscriber lines terminated at an RDT.
- A DS0 bearer circuit between the RDT and the Host Switch is not connected until the subscriber goes off-hook or until a call is received by the Host Switch which is destined for the subscriber.
- When a connection between a subscriber's line and a Host Switch is necessary, it is set up dynamically using signaling messages between the Host Switch and the RDT.
- When a call is terminated, the DS0 circuit between the RDT and the host switch is disconnected from the line and is made available for use by other subscribers.

If you purchase an item "FOB Chicago", you own the item, but you still must get it from Chicago to wherever you need it. Concentrated Access would be provided "FOB" at the RDT location. Connectivity between the RDT and an Alternative or Enhanced Service Provider's Host Switch requires dedicated transport (DS1s or VT1.5s) for the trunks from the RDT to the switch. An Enhanced Service Provider without his own alternative network could obtain Concentrated Access by leasing dedicated DS1s or VT1.5s from the RDT to his location from Special Access tariffs. A Competitive Access Provider (CAP) with an existing transport network could obtain Concentrated Access from the LEC and provide transport for trunks from the RDT to the CAP's switch using indigenous CAP facilities.

If Concentrated Access is made a tariffed service, a potential Alternate Service Provider or Enhanced Service Provider could go into business with the limited risk of only one Host Switch and still provide his unique service(s) to any subscriber in the LATA (see Figure 10).

Many of the functional capabilities desired by organizations such as the Coalition of Open Network Architecture Parties (CONAP) [15, 16] can be provided using Concentrated Access. An Enhanced Service Provider does not have a functional requirement to control the call processing of an End Office switch belonging to a LEC. The functionality required is to economically and efficiently get access to subscriber lines anywhere in a LATA and somehow avail these subscribers of the ESP's unique features. This can be accomplished by using Concentrated Access to connect subscribers to a switch under the Enhanced Service Provider's direct control. Figure 11 illustrates this. A switch is connected to an Adjunct which executes the Enhanced Service Provider's unique service logic.

If an ESP prefers not to own its own switch, access to an ONA capable switch within the LATA can be provided using Concentrated Access just as explained previously for ISDN. However, the time required to develop and deploy ONA, combined with its technical risk would seem counterproductive when the low risk RDT based solution can be available sooner and with far less software development.

Figure 10. Using Concentrated Access, an Enhanced Service Provider's host switch can be located anywhere. It connects via DS1s to a SONET ADM, then to Virtual RDTs in each wire center which serves subscribers who have chosen the Alternate or Enhanced Service Provider for local service. As with an RBOC introducing ISDN, Provider A's financial risk is limited to one switch until his market penetration justifies adding more capacity. Also, as with ISDN, an Enhanced Service Provider need not wait for ONA to be deployed throughout a LATA in order to offer services to any potential subscriber in the LATA.

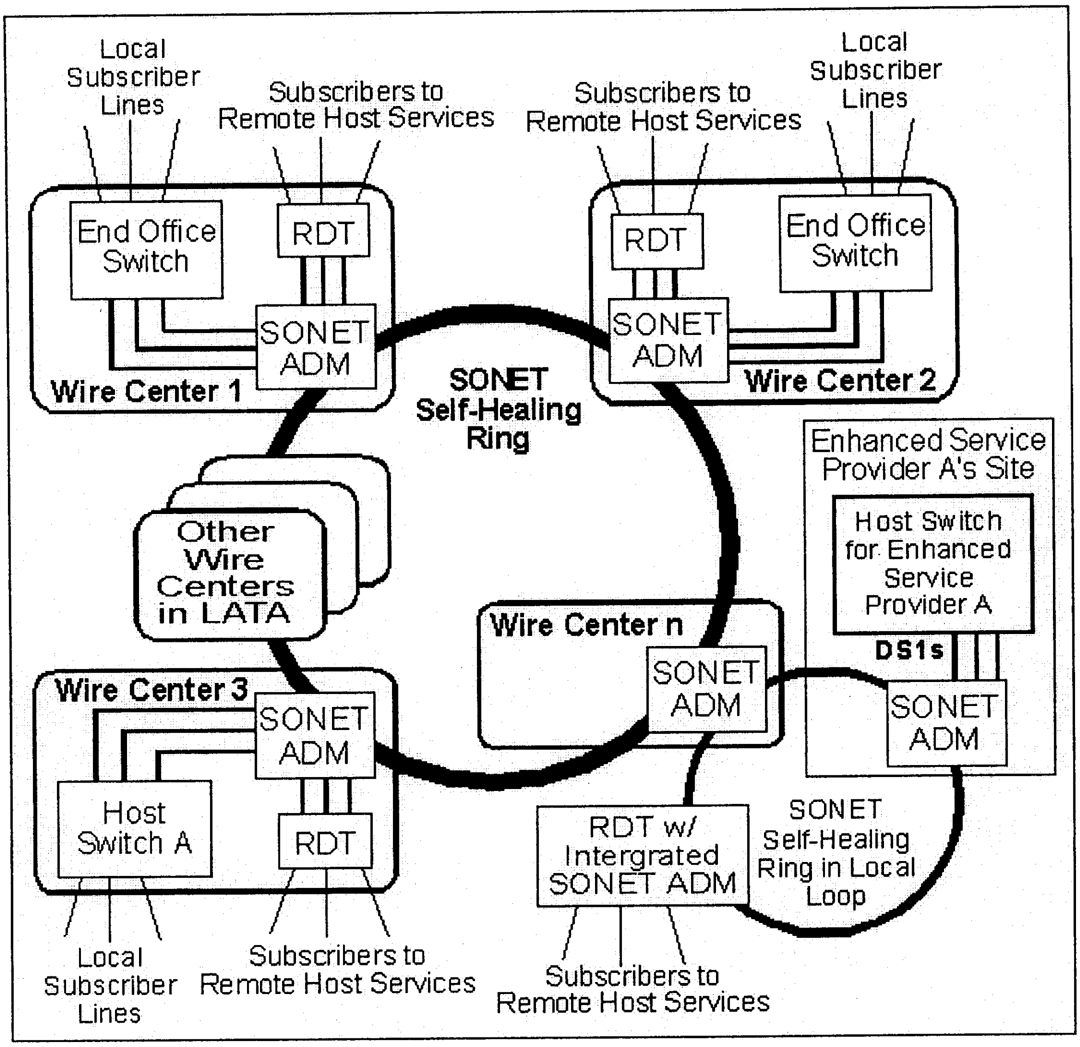
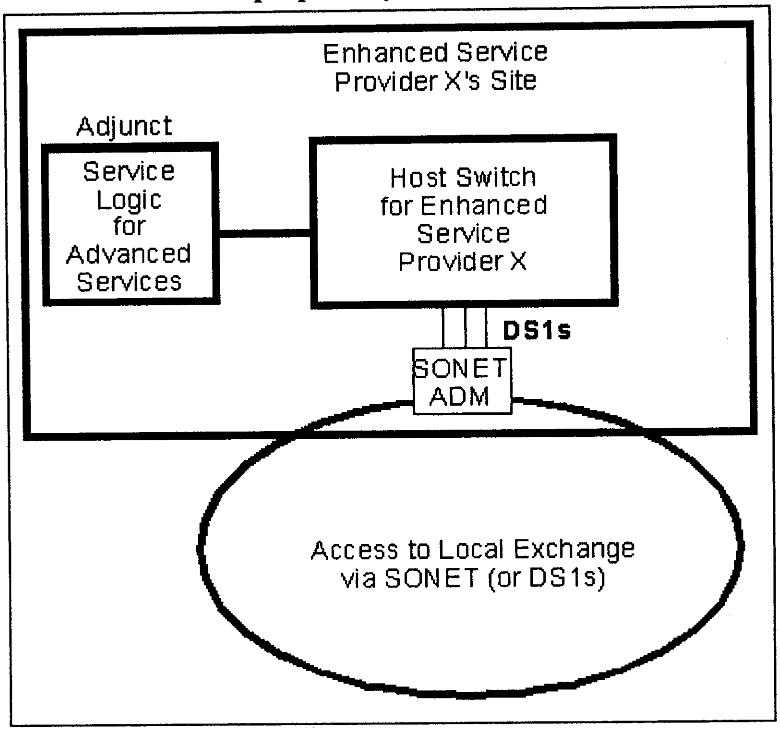


Figure 11. An Enhanced Service Provider might offer traditional switch-based services while an ESP could offer advanced services via an Adjunct programmed with the ESP's own proprietary Service Logic.



While an IDLC must conform to strict environmental requirements to be installed by a LEC in the Loop or a CO, a device which conforms to TR-303 interface specifications using the Common Signaling Channel can easily be built using a Personal Computer equipped with an assortment of boards built for "Voice Processing". Available boards include T1 interface cards, Time-Slot Interchangers and Line Interface Cards. Without the redundancy required for high availability in the Public Switched Network (PSN), such a box could be produced at a relatively low cost. This could provide an intelligent digital interface between the customer's computer applications and either LEC or Enhanced Service Provider switches using Concentrated Access (see Figure 12). Many of the capabilities available with emerging interface standards such as the Switch to Computer Applications Interface (SCAI) and the Open Application Interface (OAI) [17] could be provided simply and efficiently using this technique.

This example suggests that a service provider might consider allowing a Customer Premise Equipment (CPE) based RDT to connect to it's switches using Concentrated Access. However, Concentrated Access as proposed herein merely refers to being able to connect a LEC's Multihosting RDT to a non-LEC switch. If an existing LEC is concerned about allowing customer owned (and programmed) RDTs to connect to their switches they need not permit it. In today's competitive environment someone will be willing to address this potential market, even if they initially sell integrated CPE and host based enhanced services to ensure that the CPE does not compromise their switch security.

6. Other Brief Comments.

The deployment of TR-303 compatible RDTs in the typical loop applications could be limited by the same problem which delays ISDN deployment. That is, CO switches must first be digital and second must be configured with special hardware, the Integrated Digital Terminal (IDT), and companion software. Upgrading many COs to TR-303, like upgrading many switches to ISDN, would thus, be a slow and expensive process. However, the approach introduced by Eaves and Zimmerman will enable the rapid deployment of IDLC capabilities. By hosting RDTs to a few TR-303 equipped switches in a LATA, the advantages of TR-303 RDTs, including flexible provisioning and maintenance, can be achieved more rapidly than otherwise envisioned. With FITL systems complying with TR-909 [18] also using the TR-303 interface to the host switch, such installations could also be expedited without the need to use the limited TR-08 Integrated interface or a COT type interface to local analog switches (see Figure 13).

7. Conclusion.

Providing Concentrated Access using the Multihosting or Virtual RDT concept is the essence of local access. It provides access to subscriber lines without the need for dedicated special access circuits for each subscriber's line. It decouples switching and software based services (which can be provided from a remote host) from functions which can be performed by standardized commodity transmission products available from many vendors. Concentrated Access can provide the key which unlocks the Local Exchange Network to open and fair access to all.

Figure 12. Using available PC compatible Voice Processing boards, a TR-303 compatible RDT can be integrated providing Computer Integrated Telephony capabilities coupled with the advanced services available from the Enhanced Service Provider.

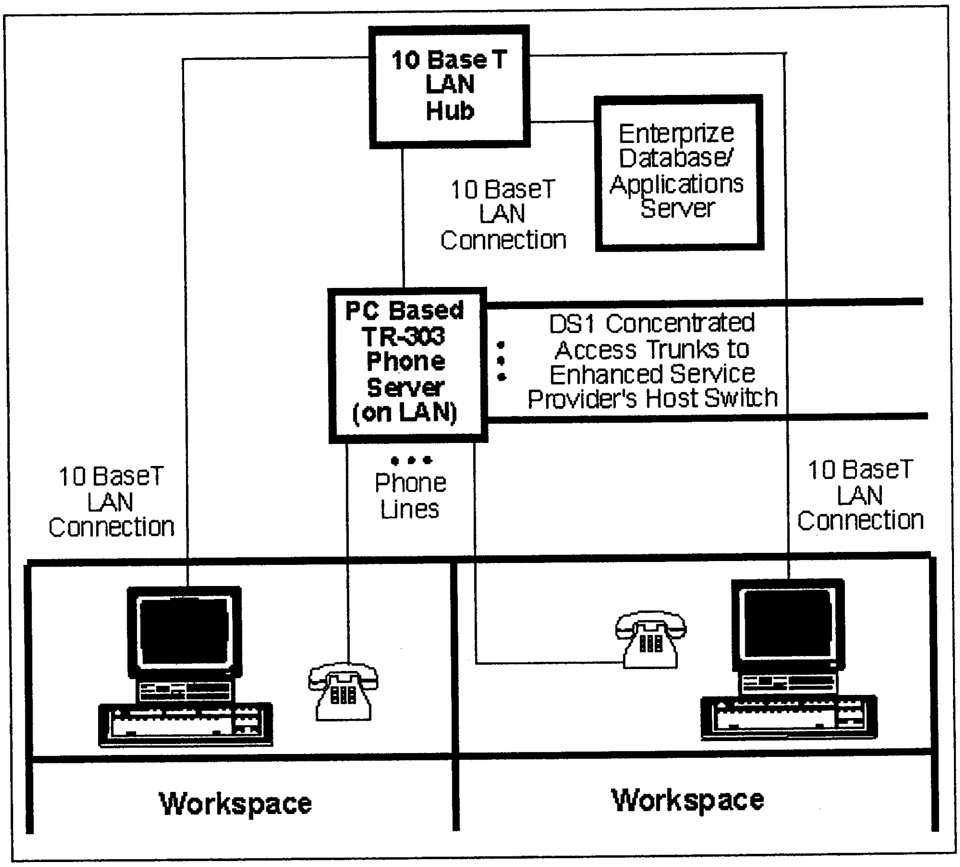
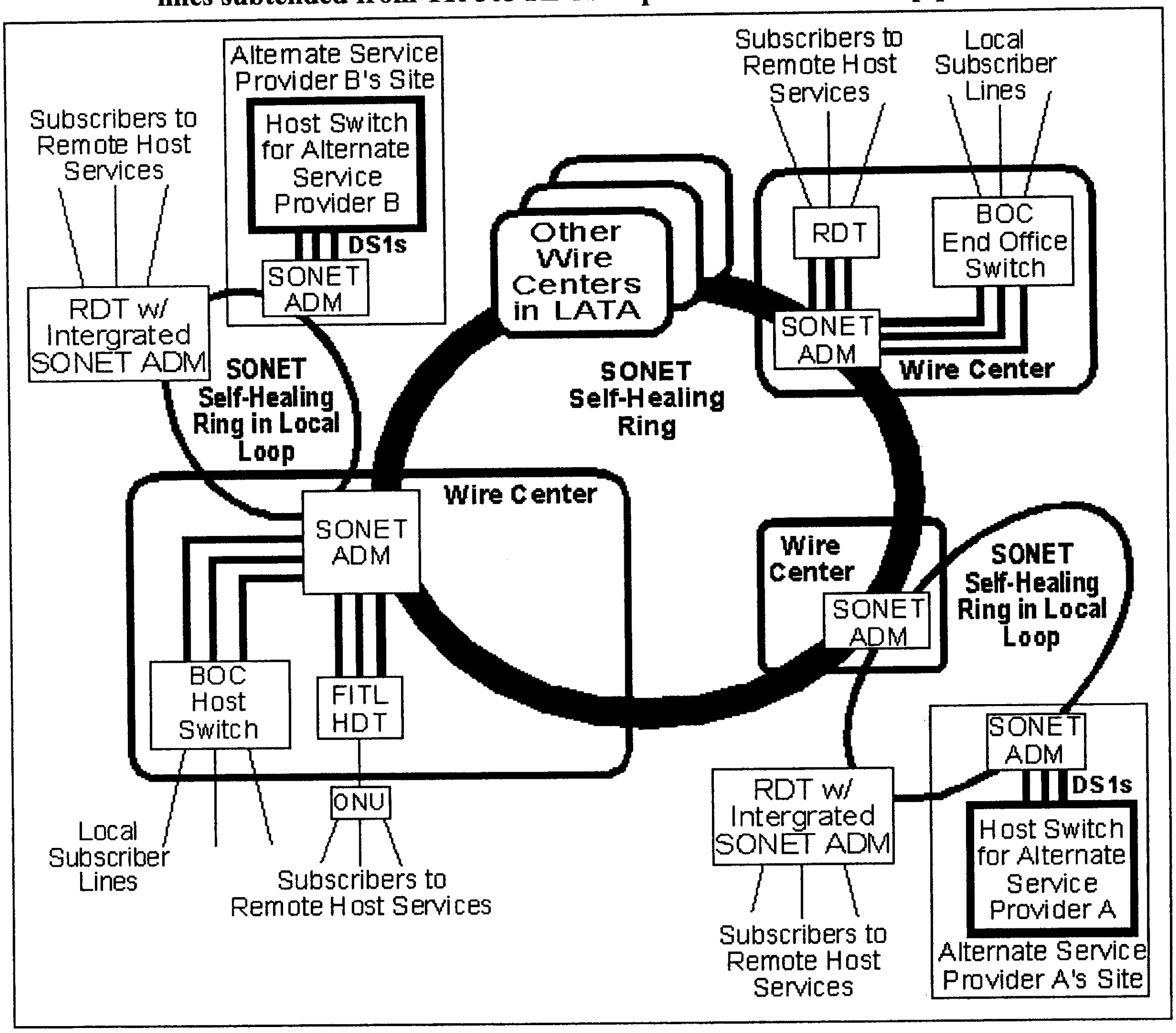


Figure 13. A TR-909 compliant fiber-in-the-loop Host Digital Terminal (HDT) interfaces to an End Office Switch like a TR-303 RDT. Thus, Alternate Service Providers would have access to subscribers subtended from an Optical Network Unit (ONU). Furthermore, provision of a tariffed Concentrated Access service using TR-303 would provide access to lines subtended from TR-303 RDTs dispersed within the Loop plant.



Footnotes

1. SLC is a Registered Trademark of AT&T.

2. For the sake of simplicity, references to the Time-slot Management Channel (TMC) used for hybrid signaling are not discussed in this paper.

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Unbundled Wire Pairs, Special Services, and ISDN DLC Grooming

The Challenge

For years telcos have struggled with the trade-off between Integrated DLC economies and Universal DLC flexibility. By eliminating the COT, TR-8 Integrated DLCs provide low-cost POTS, SPOTS™, and coin services. On the other hand, Universal DLCs accommodate these services, in addition to Special Services, ISDN, and today's new requirements for "unbundled loops" — i.e. wire pairs routed to a competitive local exchange carrier (CLEC).

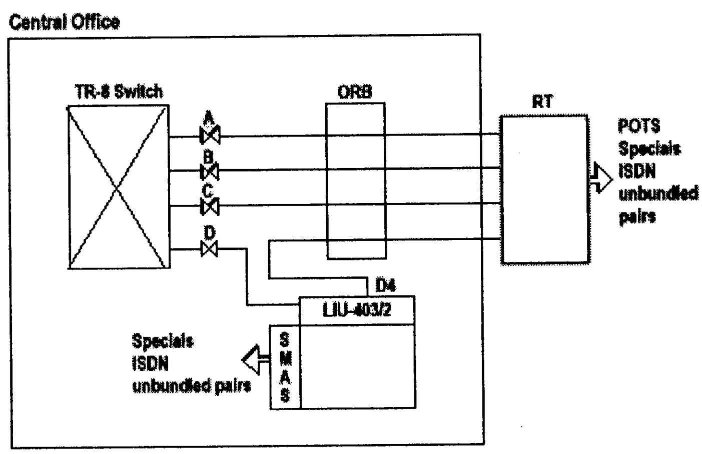
While large COs may have a DCS or NGDLC capability to groom some of these circuits, such an approach can be quite expensive. And, in small COs, these costs can be still more problematic. Some applications have even required an expensive conversion from Integrated Mode back to Universal Mode just to provide a few ISDN circuits.

What telcos need, therefore, is a solution that combines the benefits of both systems: the low costs of Integrated DLCs and the flexibility of Universal DLCs. Pulsecom's LIU-403/2 supplies this solution with a highly cost-effective tool for Integrated DLC grooming of ISDN, Special Services, and unbundled wire pairs.

The Pulsecom Solution: *The LIU-403/2 can be used to groom ISDN, Special Services, and unbundled wire pair circuits much*

Customer Gateway

Overview



more cost-effectively than Universal DLCs or other alternatives.

The Pulsecom Solution

Pulsecom's LIU-403/2 provides an immediate, ubiquitous, and cost-effective solution. Deployed in the LIU common slot of a standard D4 or WECO/AT&T/Lucent chassis, the LIU-403/2 is placed between the ORB and a Mode I TR-8 switch, where it serves digroups B, C, or D, and a conventional Integrated DLC RT. Then, by utilizing simple local provisioning, ISDN, Special Services, or even POTS/SPOTS circuits can be routed to local, conventional VF/DDS terminations. Other than this circuit pack, all other mountings, as well as all common and most VF/DDS terminations, are standard office/PICS inventory.

Locations utilizing SMAS may choose to perform circuit tests with standard unitized or stand-alone Pulsecom or WECo/AT&T/Lucent SMAS equipment.

The LIU-403/2 makes use of the fact that digroups B, C, and D of a Mode I TR-8 Integrated DLC system utilize standard D4 framing. The DS1 from the ORB is routed to the standard "D4 digroup A" connections on a D4 chassis. Special Service/ISDN or POTS/SPOTS channels that are to be dropped at this chassis are selected by front panel switches on the LIU-403/2, and the remaining DS0 circuits are passed to the "D4 digroup B" D4 chassis terminations for connection to the TR-8 switch. To accommodate various office cable lengths, DSX-1 levels are selected via standard TPU equalizers.

The LIU-403/2, along with the existing D4 chassis, common units and, in most cases, channel units are utilized to provide virtual universal access in Integrated DLC systems. Exceptions include: "unbundled" POTS/SPOTS terminations, which require a D4 2FXO that supports TR-8 signaling, such as Pulsecom's DPTGT-FXOGT, and coin service, which is supported via digital tandem connections rather than VF pairs.

Major Benefits

- **Cost-Effective** — The LIU-403/2 makes use of the existing infrastructure to provide a highly cost-effective method for grooming a wide variety of circuits.
- **Flexible** — Like Universal DLCs, the LIU-403/2 supports an entire range of services, including POTS, SPOTS, coin, Special Services, ISDN, and unbundled loops.
- **High Quality** — Unlike Universal DLC access, LIU-403/2 grooming need not introduce additional analog-to-digital or digital-to-analog conversions.

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For more information on Pulsecom products and solutions, please call our Customer Service Department at 1-800-381-1997 (or 703-471-2950).

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